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Comprehensive Evaluation on China's Industrial Structure Optimization from the Perspective of Coordination

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***Abstract*—**From the perspective of industrial structure coordination and based on an explicit definition for the connotation of industrial structure coordination, the synergetic coefficients are used to measure the coordination degree between three industries' input structure and output structure, and then the efficacy function method is employed to comprehensively evaluate the level of China's industrial structure optimization. It is showed that Chinese industrial structure presented a "v-shaped" variation tendency between 1996 and 2008, and its industrial structure adjustment got obvious achievements after 2003, with the industrial structure optimization level increasing continuously. However in 2009, the level of China's industrial structure optimization declined sharply due to the decreasing contribution degree of value added structure and energy structure coordination and the lower coordination degree of value added structure and capital structure.

***Keywords*—**China's industrial structure, Coordination degree, Efficacy function, Synergetic coefficients

I. Introduction

THE industrial structure is constantly variable with social and economic growth. The adjustment and optimization of industrial structure can reflect the essential and benign development of economy. Adjusting the industrial structure, so as to promote the coordinated development, is an important basis for realizing stable and sustainable development of Chinese economy (Zhang, 2011[1]). The strategic adjustment of the economic structure serves as the main direction of attack during the Twelfth Five-Year in China, where industry structure adjustment is the key element.

According to the research results of scholars and the experiences of developed countries, the industrial structure optimization direction should evolve from "primary, secondary and tertiary" to "secondary, tertiary and primary", then to "tertiary, secondary and primary". Therefore, the proportion of three industries is often used to measure the degree of industrial structure optimization. However, the industrial structure optimization not only means relationship and evolution law between the three industries, but also refers to the coordinated development of input structure and output structure inside each industry. From the perspective of industrial structure coordination, and beginning from the relationship between input structure and output structure of the three industries, an empirical evaluation on Chinese industrial structure optimization will be done in this paper, so as to reflect the achievement of China's industrial restructuring.

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II. Literature Review

Industrial structure optimization is the process to promote the rationalization and supererogation of industrial structure, and the state to realize the adaptive development of industrial structure with the resource supply structure, technical structure, and demand structure, which is the core content and goal of industrial structure adjustment, and also the basic guarantee for promoting sustainable economic development. It includes supply structure optimization, demand structure optimization, international trade structure optimization, international investment structure optimization, and etc.

The industrial structure optimization has very deep connotation, which is analyzed by scholars from different points of view. Though there are differences, industrial structure optimization including two aspects, or rationalization and supererogation of the industrial structure, is widely believed. Base on this, Song (2000) [2], Cheng & Lu (2001) [3], Lei (2009) [4], and etc., set up the measuring index, and then assessed the optimization level of China's industrial structure.

Different from these scholars' research, we will evaluate Chinese industrial structure from the perspective of industrial structure coordination, because industrial structure coordination is closely related to industrial structure optimization, or embodies the fundamental connotation of industrial structure optimization. Zhang & Yuan (2003) [5] considered that the goal of industrial structure coordination was that industrial structure tends to be rationalized, and the industrial structure coordination itself was a process of industrial structure supererogation. In Lv's (2009) [6] opinion, industrial structure coordination was industrial structure rationalization, and also reflected the contents of industrial structure supererogation. Therefore, we can evaluate the level of industrial structure optimization from the perspective of coordination.

The literatures which evaluate the industrial structure optimization based on coordination can be divided into two categories. The first category used input-output table and adopted input-output analytical method in evaluation, so as to provide theoretical basis for industrial structure adjustment (Shi, 1998[7]; Tang, Liu & Liu, 2010[8]). The second category studied the contents of industrial structure coordination, such as the coordination between industrial structure and investment structure (Zhang, 2006[9]), or between industrial structure and employment structure (Wang, 2010[10]; Wu, 2010[11]).

Input-output table is the basis of input-output analysis, but input-output table is not available every year. Since we attempt to comprehensively evaluate the level of China's industrial structure optimization in a continuous period of time, input-output analysis is not suitable, so we will do the evaluation based on the contents of industrial structure coordination. Though abundant research results were achieved, they were studied only from one certain aspect of industrial structure coordination.

Because of the rich connotation of industrial structure coordination, assessing the coordination only form aspect is insufficient. Based on explaining the contents of the coordination, a model will be built up in this paper to comprehensively assess China's industrial structure optimization level from 1996 to 2009, thus supplementing current researches.

III. Methodologies

A. Connotation of Industrial Structure Coordination

The industrial structure coordination includes coordination between the three industries and inside each industry. Because the three industries' relationship is the most basic relationship in national economy, reflecting the development level of a country or a region, therefore, the industrial structure coordination in this paper refers to the coordination between the three industries.

Usually, the three industries' structure can be expressed by the ratio of each industry's value added in total GDP, which is called the value added structure of three industries. According to the definition of industrial structure optimization, the value added structure should be coordinated with the resource supply structure, the technology structure and the demand structure. Though the technology structure and the demand structure are key factors in industrial structure transition, due to lacking in related data, the comprehensive evaluation on the level of industrial structure optimization will only be done from the coordination between value added structure and resource supply structure in this paper.

Under general conditions, the values added of industries are influenced by labor inputs and capital investment. In the background of sustainable development, we should also consider the relationship between energy inputs and value added output. Therefore, the resource supply structure here includes three aspects, or labor structure, capital structure and energy structure, and the three industries' coordination means coordination between value added structure and labor structure, coordination between value added structure and capital structure, and coordination between value added structure and energy structure (Fig. 1).

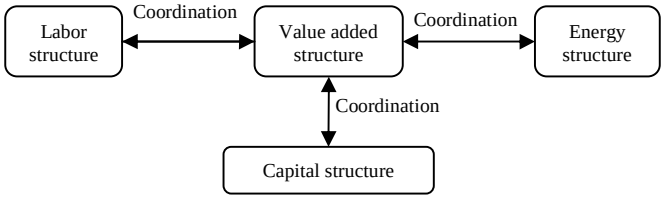

Fig. 1 Connotation of three industries' coordination

Fig. 1 shows that there is an interaction relationship between input structure and output structure. Value added structure transition determines the development direction and process of labor structure, capital structure and energy structure, and reasonable labor structure, capital structure and energy structure play an important role in promoting the industrial structure optimization.

B. Synergetic Coefficients between the Three Industries' Inputs Structure and Value Added Structure

Industrial structure coordination can be measured by deviation coefficients (He & Yao, 2008[12]) or synergetic coefficients (Xue, 2009[13]). The synergetic coefficients are adopted in this paper to assess the industrial structure optimization. Using Y, L, K, E to represent value added structure, labor structure, capital structure, and energy structure respectively, and S to represent the synergetic coefficients, then we can get:

(1) Synergetic coefficient between value added structure and labor structure (SYL);

$$SYL = \frac{\sum (Y_i \cdot L_i)}{\left[\sum (Y_i)^2 \cdot \sum (L_i)^2\right]^{\frac{1}{2}}} \quad i = 1,2,3 \qquad (1)$$

(2) Synergetic coefficient between value added structure and capital structure (SYK);

$$SYK = \frac{\sum (Y_i \cdot K_i)}{\left[\sum (Y_i)^2 \cdot \sum (K_i)^2\right]^{\frac{1}{2}}} \quad i = 1,2,3 \qquad (2)$$

(3) Synergetic coefficient between value added structure and energy structure (SYE).

$$SYE = \frac{\sum (Y_i \cdot E_i)}{\left[\sum (Y_i)^2 \cdot \sum (E_i)^2\right]^{\frac{1}{2}}} \quad i = 1,2,3 \qquad (3)$$

Here, Yi is the ratio of i industry's value added in total GDP, representing the value added structure of the three industries; Li is the ratio of i industry's employees in total employees, representing the labor structure of the three industries; Ki is the ratio of i industry's fixed assets investment in total fixed assets investment, representing the capital structure of the three industries; Ei is the ratio of i industry's energy consumption in total energy consumption, representing the energy structure of the three industries.

From formula (1), (2) and (3), we can know that synergetic coefficients S should be between 0 and 1. When S is close to 1, it means higher coordination degree of the industrial structure.

C. Comprehensive Evaluation Model of Industrial Structure Optimization

Based on these synergetic coefficients above, we can adopt the efficacy function method (Peng, Yuan & Hui, 2007[14]) to calculate the comprehensive evaluation value of industrial structure optimization under the perspective of coordination. Efficacy function method is put forward based on multi-objective programming principle. Its basic idea is transforming the actual value of indexes with different dimensions and properties into dimensionless efficacy coefficients through the efficacy function, and then getting the comprehensive evaluation value according to the weight of each index, which is served as the basis for the comprehensive evaluation. The calculating steps are as follows.

Firstly, synergetic coefficient between value added structure and labor structure, synergetic coefficient between value added structure, and capital structure and synergetic coefficient between value added structure and energy structure of each year are used as the calculating data sequence, which is showed by $(SYL)_j$、$(SYK)_j$ and $(SYE)_j$, where j denotes the year.

Secondly, use the linear efficacy function to transform the synergetic coefficients into dimensions efficacy coefficients (EC), where

$$EC[(SYL)_j] = \frac{(S_{YL})_j - 0.99 * \min(S_{YL})_j}{1.01 * \max(S_{YL})_j - 0.99 * \min(S_{YL})_j} \quad (4)$$

$$EC[(SYK)_j] = \frac{(S_{YK})_j - 0.99 * \min(S_{YK})_j}{1.01 * \max(S_{YK})_j - 0.99 * \min(S_{YK})_j} \quad (5)$$

$$EC[(SYE)_j] = \frac{(S_{YE})_j - 0.99 * \min(S_{YE})_j}{1.01 * \max(S_{YE})_j - 0.99 * \min(S_{YE})_j} \quad (6)$$

Among them, amplifying 1% of the maximum and shrinking 1% of the minimum are only a kind of data treatment need, with the purpose to avoid 0 or 1 of the efficacy coefficients.

Finally, based on the dimensions efficacy coefficients, the geometric means are used to figure out the comprehensive evaluation value of industrial structure optimization. The comprehensive evaluation value of year j is

$$V_j = \sqrt[3]{EC[(SYL)_j] \cdot EC[(SYK)_j] \cdot EC[(SYE)_j]} \quad (7)$$

V_j is between 0 and 1. $V_j = 0$ means the lowest optimization degree of industrial structure, while $V_j = 1$ represents the highest optimization degree of industrial structure.

IV. Empirical Analysis

A. Raw Data

Form Chinese Statistical Yearbook 2011, we can get the raw data, which can be used to comprehensively evaluate the level of China's industrial structure optimization from 1996 to 2009 (Table I).

TABLE I
Raw Data Sheet

Year	Y			L		
	Y1	Y2	Y3	L1	L2	L3
1996	0.197	0.475	0.328	0.505	0.235	0.260
1997	0.183	0.475	0.342	0.499	0.237	0.264
1998	0.176	0.462	0.362	0.498	0.235	0.267
1999	0.165	0.458	0.377	0.501	0.230	0.269
2000	0.151	0.459	0.390	0.500	0.225	0.275
2001	0.144	0.451	0.405	0.500	0.223	0.277
2002	0.137	0.448	0.415	0.500	0.214	0.286
2003	0.128	0.460	0.412	0.491	0.216	0.293
2004	0.134	0.462	0.404	0.469	0.225	0.306
2005	0.121	0.474	0.405	0.448	0.238	0.314
2006	0.111	0.480	0.409	0.426	0.252	0.322
2007	0.108	0.473	0.419	0.408	0.268	0.324
2008	0.107	0.475	0.418	0.396	0.272	0.332
2009	0.103	0.463	0.434	0.381	0.278	0.341

Year	K			E		
	K1	K2	K3	E1	E2	E3
1996	0.008	0.414	0.578	0.047	0.839	0.113
1997	0.010	0.399	0.591	0.048	0.831	0.120
1998	0.012	0.345	0.642	0.049	0.815	0.136
1999	0.015	0.322	0.663	0.050	0.798	0.152
2000	0.016	0.321	0.663	0.049	0.796	0.155
2001	0.016	0.307	0.677	0.052	0.785	0.163
2002	0.019	0.320	0.661	0.050	0.791	0.159
2003	0.012	0.363	0.625	0.043	0.803	0.153
2004	0.011	0.387	0.602	0.042	0.805	0.153
2005	0.011	0.421	0.568	0.040	0.810	0.151
2006	0.012	0.424	0.564	0.038	0.810	0.152
2007	0.012	0.433	0.555	0.035	0.813	0.152
2008	0.015	0.436	0.549	0.023	0.821	0.156
2009	0.031	0.429	0.541	0.023	0.820	0.157

Note: Y, L, K and E represent value added structure, labor structure, capital structure and energy structure respectively; 1, 2 and 3 represent primary, secondary and tertiary industry. All data are drawn from Chinese Statistical Yearbook 2011.

B. Calculating the Synergetic Coefficients

Using data of TABLE I and formula (1), (2) and (3), we can figure out synergetic coefficient between value added structure and labor structure (SYL), synergetic coefficient between value added structure and capital structure (SYK) and synergetic coefficient between value added structure and energy structure (SYE) of each year (Fig. 2).

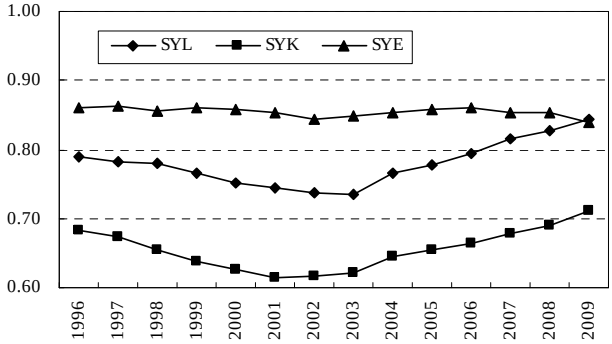

Fig. 2 Calculating results of synergetic coefficients

From Fig. 2 we know that, the overall trends of SYL and SYK are more consistent, presenting a first down and then increasing "V" type variation tendency. However, SYE is quite smoothly and declines slightly after 1997.

In particular, except in 2009, SYE has the largest value, followed by SYL and SYK orderly. SYK reaches the bottom in 2001 while SYL reaches the bottom in 2003, denoting that the coordination between value added structure and capital structure has antecedence function and also has large increasing space.

C. Evaluating Industrial Structure Optimization

Based on the synergetic coefficients above, we adopt formula (4), (5) and (6) to transform them into dimensions efficacy coefficients, and then adopt formula (7) to figure out the comprehensive evaluation value of industrial structure optimization level in every year (Fig. 3).

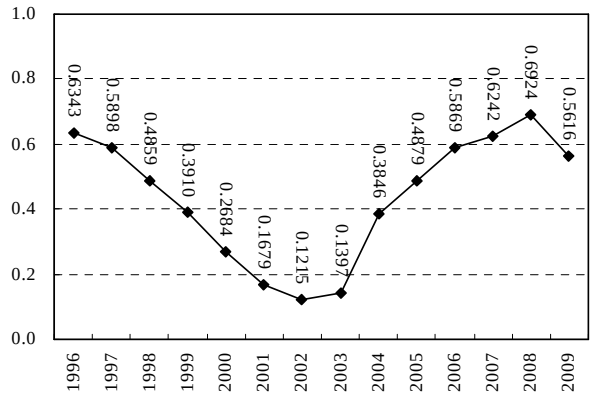

Fig. 3 Comprehensive evaluation value of industrial structure optimization level

From Fig. 3 we know that, during 1996 and 2008, the optimization level of Chinese industrial structure presents the first fall then rising "V" type trend, during which the comprehensive evaluation value dropped from 0.6343 in 1996 to the minimum value of 0.1215 in 2002, then shows a rapidly rising tendency from 2003 and reaches the maximum of 0.6924 in 2008. But the evaluation value declines sharply in 2009, means the drop in the optimization level of China's industrial structure.

V. Conclusions and Discussion

The coordination degree can be used to measure the level of industrial structure optimization. Based on defining the connotation of coordination between the three industries, the synergetic coefficients are used to measure the coordination degrees between the value added structure and different inputs structure of the three industries, the efficacy function method is then adopted to comprehensively evaluate the optimization level of China's industrial structure from 1996 to 2009.

It is showed that, during 1996 and 2008, the evaluation value presents a first down then rising change trend, especially after 2003, Chinese industrial structure adjustment gets obvious achievement, since the coordination degree between the input structure and output structure is continuously increasing.

However, much attention should be paid to year 2009. In this year, the coordination degree drops a lot. The exact reason is the declining contribution degree of SYE (Fig. 4).

The fast decline of SYE contribution degree affects the level of China's industrial structure optimization, which is rising from 2003 due to increasing contribution degree of SYL and SYK, while falling in 2009, since the declining tendency of SYE contribution degree is larger than the increasing tendency of SYL and SYK contribution degree. Another reason is the lower coordination degree of value added structure and capital structure, which has already been explained in Fig. 2.

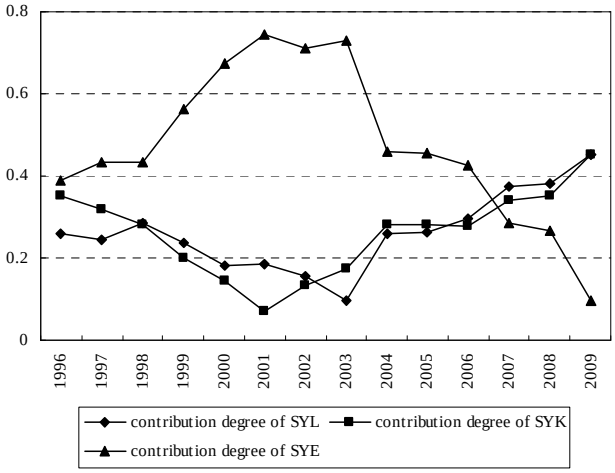

Fig. 4 Contribution degrees of SYL, SYK and SYE in comprehensive evaluation value

Therefore, we should optimize the energy structure, so as to improve the level of Chinese industrial structure optimization. Of course, because SYK is smaller than SYL and SYE, we can also adjust the capital structure, develop the leading role of Y-K coordination in promoting Y-L coordination and Y-E coordination, so as to raise the level of Chinese industrial structure optimization.

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